Space Weather Technical Forecast

Issued on Sunday, 07 January 2024 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1 considered Likely throughout. Slight Chance of G1 throughout. Waning Chance of S1.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as measured by GOES16 was Low, with frequent low to mid-ranking C-class flares and with a peak of C7.1 seen at 06/1535UTC from sunspot region AR3538 in the northwest quadrant. There are now up to ten sunspot regions on the solar disc, although the partitioning of some of these is quite fluid given their diffuse nature. AR3540 in the southeast remains the largest spot on the disk, now with two weak delta spots present, one in each of the leading and trailing portions. AR3536 near centre-disc, also saw development in its leading region, with a ring of spots of opposing polarity and a reformation of a delta region. The other notable increase was from the new region near centre disk just south of the equator, this spot is developing quickly, though only with rudimentary penumbra at present. All other spots have shown little change, and are comparatively simple.

A filament eruption and subsequent CME was seen to emerge from the northeastern quadrant around N30E30 at 06/1330UTC. This CME passes 1AU around the turn of the UTC day 09 into 10 January as a very slight glance. No further Earth-directed CMEs have been observed at this time.

Solar Wind / Geomagnetic Activity: Solar winds, as measured at L1 by ACE and DSCOVR showed level but differing values near background levels in an apparent slow regime. The solar wind speed was variously described as in the low 300s or else high 400s by each satellite, with the former perhaps preferred (ACE) given the expected and preferred slow regime, and the fact that the solar wind density and IMF were otherwise small-scale and unremarkable (within single figures ppcc and below 3nT respectively, with a north-south component of +2/-3nT). The phi angle was mostly negative (towards the Sun).

The net result of the above solar wind measures gave Quiet geomagnetic activity throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux continued its slow decline of recent days towards resting background levels, now averaging around 1.3pfu (below S1).

GOES16 high energy (greater than 2MeV) electron flux was at Normal Background levels. The 24-hour fluence was below Active throughout, with a flat trend. The 07/0001UTC observation was 2.26e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a level daily Chance of M-class flares throughout, and a Slight Chance of X-class.

Solar Wind / Geomagnetic Activity: Up to two CMEs feature at present and one fast wind regime. The most likely course of events is for the fast wind to arrive within the first 24 hours, with the northeast quadrant CME from 05 January then due in the following 24 and the second east-central CME from 06 January perhaps following after yet another 24 hours - each with

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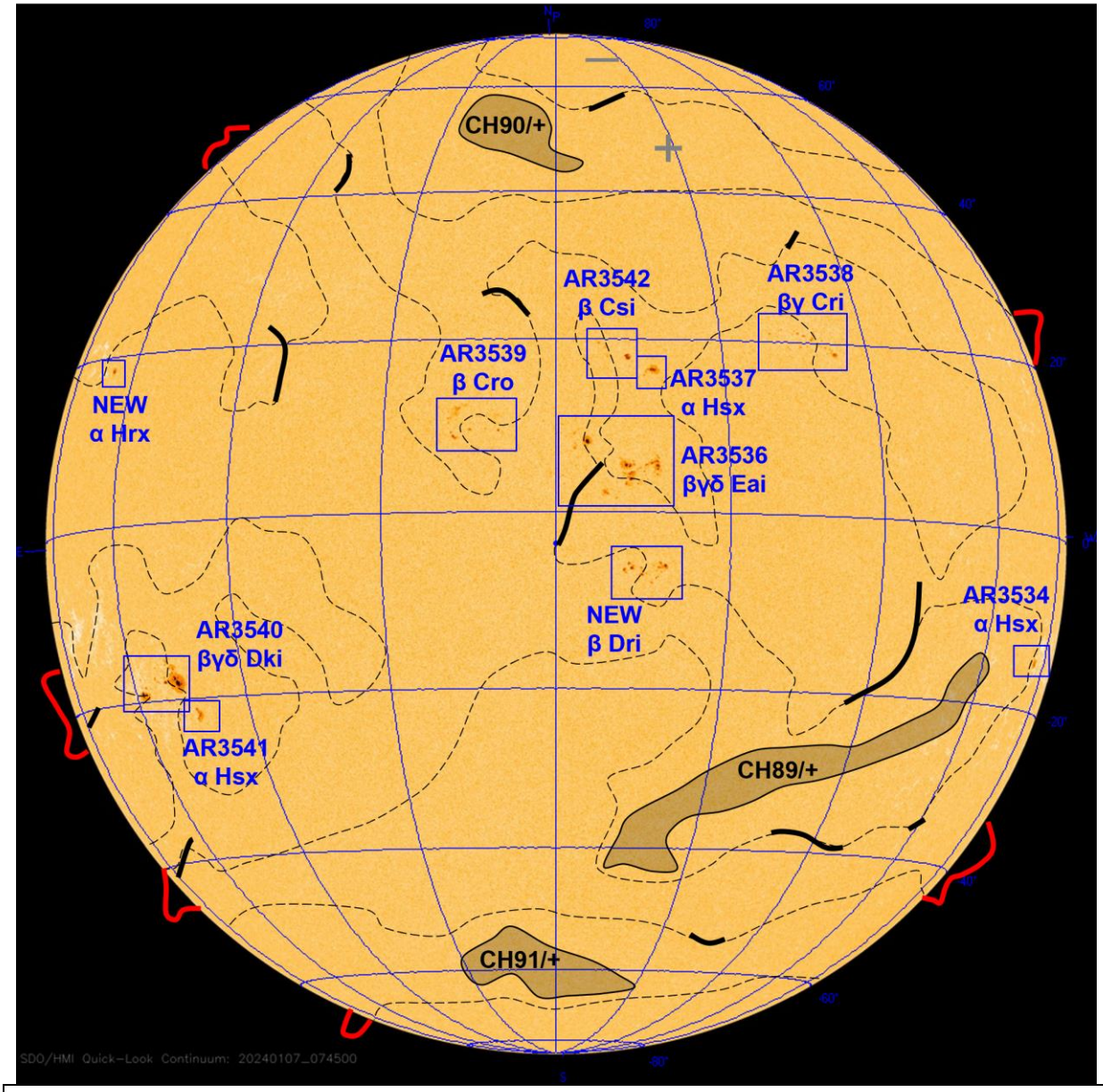
decreasing confidence.

The net result is a falling Slight Chance of G1 through the four days, perhaps most reliably Quiet at the very start and end of the period.

Energetic Particles / Solar Radiation: In the absence of further proton-rich flares in prone locations, levels may be allowed to relax back to resting background before the middle of the coming UTC working week, with a Chance of S1 falling to a Slight Chance with time.

High-energy electrons at GEO are expected to remain at Normal Background levels in the near-term, with a rising Slight Chance of Active 24-hour integrated fluence before midweek UTC in the wake of CH89's fast wind and in the possible absence of significant CME effects.

Figure 1. Solar Analysis Valid 07/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

Two CMEs feature in the current forecast. The first originated from the northeastern quadrant on 05 January (but directed southeastward) and is forecast to perhaps glance the Earth either late on day 2 (08 Jan) or else during day 3 (09 Jan). Secondly, the filament eruption observed at 06/0620UTC has been provisionally determined to pass 1AU around the turn of the UTC day 09-10 Jan as a very slight glancing blow. Confidence in this second CME is especially low given that the analysed CME appeared to be better described by a more eastward-directed CME than its departure point on the disc might suggest (i.e. it apparently did not leave purely radially outward).

Earth is currently thought to be transiting a sector of space dominated by a slow solar wind regime. A fast wind from coronal hole 89 may interrupt this later in the current UTC day of 07 Jan or on 08 Jan, with speeds in the region of 450-500km/s possible. These speeds should then continue until slowly waning through 09 Jan. This coronal hole is a recurrent feature which produced limited effects on the previous rotation, but which appears to be visually stronger on this rotation. Possibly mitigating against any significant effects are its relative location well south of the solar equatorial plane. As the coronal hole high speed stream and first CME are forecast to affect the Earth around the same time, there is uncertainty about potential speeds, with the speed of the CME also forecast at around 400-450km/s.

The result of the above factors is a Slight Chance of G1 throughout the four-day period, probably greatest in the first half under the possible combined influence of the fast wind (or its CIR) and the CME, with the second half of very low confidence and perhaps lapsing to Quiet conditions, unless the second CME has glancing impacts on 09 or 10 Jan with a possible Unsettled or Active intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	10	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
05/1746	Partial	Filament	NE	393 km/s	At or after 08/1800 UTC	Low confidence
06/2014	Partial	Filament	E Central	480	At or after 10/0001 UTC	Low confidence

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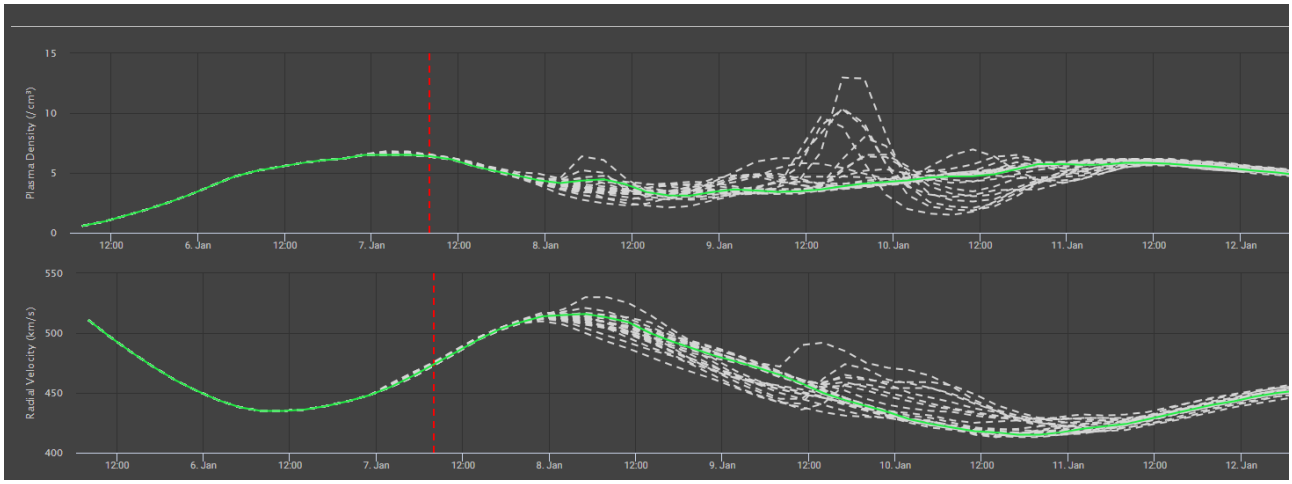
Figure 2: MOSWOC ENLIL Ensemble showing arrival of up to two CME's later in the period.



Radio Blackouts - X-Ray Flares:

Activity has been Low with the peak flare a C7.1 at 06/1535UTC from AR3538 in the northwest. There are a large number of sunspots on the current disc, and despite a recent lack of activity, it is felt that M-class flares are considered Likely with a Slight Chance of X-class flares. This risk is conserved throughout the period due to the balance between possible sunspot complexification and simplification across the main two sunspot regions on the visible disk.

There are now up to ten sunspot regions on the solar disc, although the partitioning of some of these is quite fluid given their diffuse nature. AR3540 in the southeast remains the largest spot on the disk, now with two weak delta spots present, one in each of the leading and trailing portions. AR3536 near centre-disc, also saw development in its leading region, with a ring of spots of opposing polarity and a reformation of a delta region. The other notable increase was from the new region near centre disk just south of the equator, this spot is developing quickly, though only with rudimentary penumbra at present. All other spots have shown little change, and are comparatively simple.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

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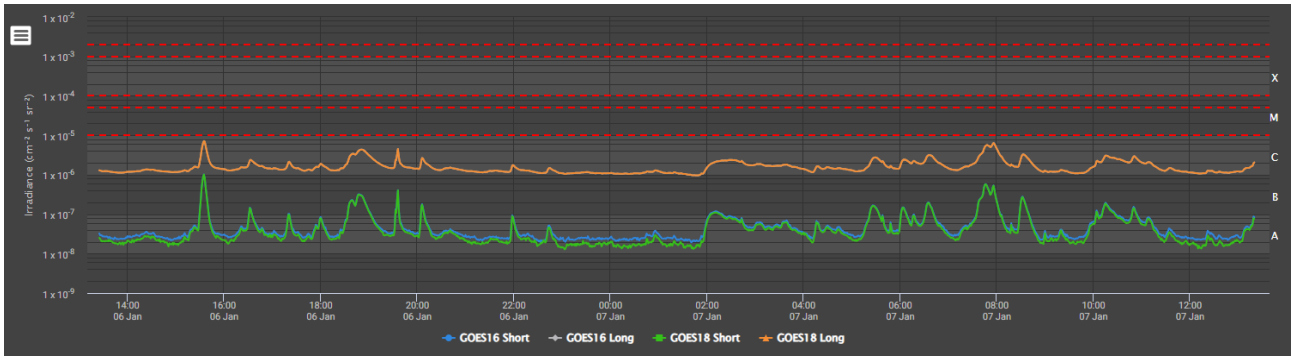
Figure 3: 24 hour X-ray trace



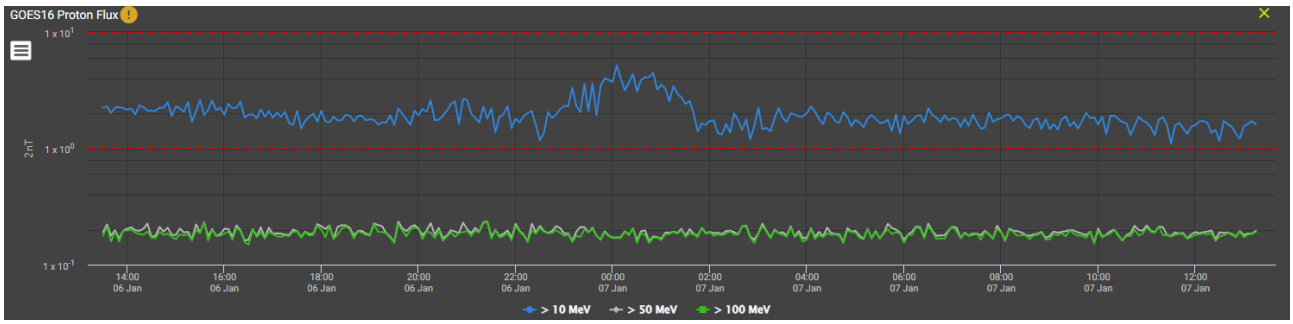
Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux remains above resting background levels in the wake of the possible generating X-class flare that greeted the new year. The soft spectrum and very gradual rise and fall certainly suggest a far-side or east limb source. Flux levels will most likely continue their very gradual relaxing trend in the coming days, however inbound CMEs may compress some of the inbound trickle of protons into a larger pulse, which overall leads to an initial Chance of S1 - i.e a little above that suggested by the raw disc probabilities (nearer 10% daily risk).

In the absence of further proton-rich flares in prone locations, levels may be allowed to relax back to resting background before the middle of the coming UTC working week, with a Chance of S1 falling to a Slight Chance with time.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24 hour proton trace



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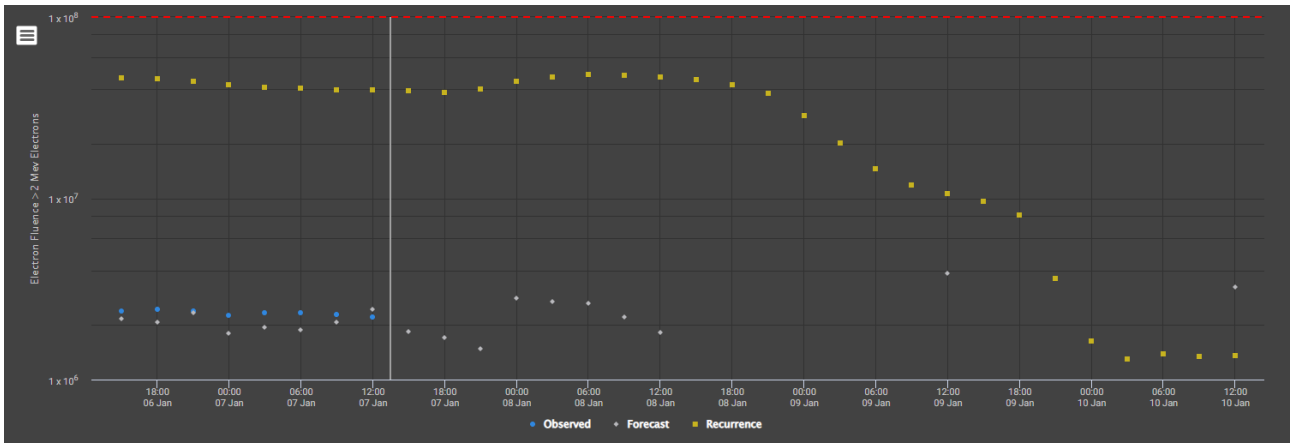
High Energy Electrons Event (≥ 2MeV):

The normal background level high energy electron flux (greater than 2MeV) at GEO is expected to continue in the near-term in the absence of any fast wind enhancement and with the uncertainty tied to inbound CMEs. Should CH89/+ materialise into the new UTC working week, there may be an eventual slight increase observed, although both persistence and the expected strength of any fast wind suggest that this is perhaps only an eventual Slight Chance. This may be further dented by any second inbound CME, and the presence of this and the earlier transient are likely to render confidence in MOSWOC REFM relatively low throughout, even if its suggested trend happens to be the favoured scenario - as now.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM fluence forecast/observations/recurrance.



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